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TITLE

Assessment of Dental Student Posture in Two Seating Conditions using
RULA methodology – A Pilot Study

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ABSTRACT

Objectives: To assess dental students' posture on two different seats in order to determine if one seat predisposes to a difference in working posture.

Design: A between-subject experimental design was selected.

Setting: The study was undertaken at the University Of Birmingham School Of Dentistry, U.K, 2006.

Subjects (Materials) and Methods: Sixty 2nd year dental students at the University of Birmingham who were attending their first classes in the phantom head laboratory were randomly selected and allocated to two different seats (30 Bambach Saddle Seats and 30 Conventional Seats). Students were trained in the use of the seats. After 10 weeks, the students were observed, photographs were taken by the researcher and these were assessed using Rapid Upper Limb Assessment (RULA).

Main Outcome Measures: The posture of the students was assessed using the RULA. Each student was given a risk score. A Mann Whitney test was used for statistical analysis.

Results: The results indicated that the students using the conventional seat recorded significantly higher risk scores ($p < 0.05$) when compared with the students using Bambach Saddle Seat, suggesting an improvement in posture when using the Bambach Saddle Seat.

Conclusion: RULA has identified that dental students using a Bambach Saddle Seat were able to maintain an acceptable working posture during simulated dental treatment and this seating may reduce the development of work related musculoskeletal disorders.

INTRODUCTION AND BACKGROUND

In the recent times, dentistry has been considered as a demanding profession due to the need for high concentration and precision¹. Work-related musculoskeletal disorders, especially of the neck and upper limbs, have become common among dentists²⁻⁷, most notably with low back pain⁸. Such injuries may lead to premature retirement⁹. Current dental practice has the dentist working in a sitting position at one side of the patient, who is in a supine position¹. The dentist also will generally have a chair-side assistant sitting at the other side of the patient⁴. Because of the restricted work area (the mouth), and the need for dexterity, the dentist may need to adopt inflexible work postures. This results in static activity of the muscles in awkward postures and may lead to musculoskeletal disorders. For example Lake¹⁰ reported that dentists who qualified in Canada spent approximately two-thirds of each treatment hour in 19-54 degrees of forward trunk inclination, which increased disc pressures considerably¹¹, when compared to standing.

The aim of this study was to investigate whether modification of seating improves posture in dental students.

SITTING POSTURE

Grandjean¹² describes sitting as 'a natural human posture' because it relieves the person of the need to actively maintain an upright posture. This reduces the static muscular workload required to maintain the joints of the foot, knee, hip and spine, with a consequent reduction in the energy consumption. Seating may improve stability and performance in tasks that require fine or precise upper limb movements. Sitting reduces

the weight bearing on the lower limbs, allowing an improved posture for foot control operations. However, sitting in a slumped posture may contribute to the development of musculoskeletal disorders e.g. Low Back Pain and Neck Pain¹³. Prolonged sitting may slacken the abdominal muscles and slump the spine^{13, 14}. This, in turn, increases the strain of spinal ligaments and stretches the back muscles¹³. If this posture is adopted over time, fatigue and back pain may be reported^{15, 16}. This slumped posture also increases vertebral disc pressure, again presenting as back pain¹⁴ and may eventually lead to disc herniation¹⁷. This back pain may also impair the activation of transverses abdominis muscles¹⁸ and oblique abdominal muscles¹⁹. These muscles are responsible for stabilizing the spine and for postural control of trunk during seated postures¹⁸; the postural activation of these muscles may be impaired in using slumped seated postures. It has been found that the activity of the oblique abdominal muscles was significantly higher in standing and seated postures when compared to lying, suggesting an important role in sustaining gravity loads¹⁹ and stabilizing these postures.

Pheasant²⁰ argued that the action of sitting down on a seat of 'average' height involves flexion of the knees and hips to about 90 degrees in each. The comfortable limit of hip joint flexion is about 60 degrees from the vertical, beyond which the passive tension of the hamstring muscles increases, which, in turn, pulls the pelvis backwards to about 30 degrees. This results in kyphosis of the lumbar spine (posterior pelvic tilt) (Fig. 1). The tension in the hamstring muscles alters when the angle of knee flexion and hip flexion varies in sitting. When a person is seated with the hips at 60 degrees from the vertical with a forward sloping seat, the

tension in the hamstring muscles are relieved and the pelvis is pulled forward. This, in turn, results in lordosis of the lumbar spine (anterior pelvic tilt, Fig. 1). Pynt²¹ recommended lumbar lordosed seated posture, regularly interspersed with movement (lordosis to kyphosis) as the optimal sitting posture, which is necessary to maintain lumbar postural health, and the prevention of low back pain. The Bambach Saddle Seat (BSS) is designed to facilitate this position.

METHODOLOGY

Research Design

A between-subject experimental design was selected. The postures in two different seats with different subjects performing the same dental procedure were compared. The working posture adopted by each student was evaluated using Rapid Upper Limb Assessment²² (RULA, Fig. 2). RULA is a survey method originally developed to assess posture in ergonomic investigations in workplaces where work-related upper limb disorders are reported, such as in VDU Operators and operators working in a variety of manufacturing tasks²². Since dentists work in a prolonged sitting posture, which resembles some manufacturing tasks, it could be considered that RULA would be a useful tool in assessing working posture of dentists.

Ethics

The research was approved by the School of Health Sciences, University of Birmingham ethics committee.

Participants:

The aim and nature of the study was introduced to all the Year 2 dental students at the Dental School who were attending their first classes in the phantom head laboratory. Ninety students were provided with information sheets and consent forms. The students were asked to return the forms if they were willing to participate in the study. Sixty students were selected at random from the 80 students who returned the forms and agreed to participate in the study. The students were randomly selected using a random number generator²³ and allocated to two types of seats. Thirty students were provided with Bambach Saddle Seat (BSS) and 30 students were provided with the Conventional seats (CS).

Training:

The students attended a lecture on the use of seats before commencement of the study. The students were followed up during the first two weeks on their sessions in the phantom head lab and individually trained for 5 to 10 minutes on correct operating posture respective to their seats.

Materials:

- a. BSS (Fig.3)
- b. CS (Fig.4)
- c. Phantom Head Apparatus (Fig. 3 & 4)
- d. Digital Camera (Nikon Coolpix 8400, Tokyo)

Assessment Procedure:

After 10 weeks, photographs were taken of the students whilst working in the phantom head lab. The positions recorded on the photographs were assessed using RULA.

The guidelines considered for taking photographs were:

- Photographs were used to allow analysis of the student's posture at a later date. Photographs are taken in all possible views of the student in order to enable viewing of all joints to be analysed.
- Photographs were taken ten minutes after the student had started the dental procedure, which was considered sufficient to allow time for the student to become comfortable in their operating position.

RULA

The RULA method uses diagrams of body postures and three scoring tables to provide evaluation of exposure to risk factors by providing a risk score. The RULA scoring sheet is schematically shown in Fig 2. According to RULA, the body is divided into two segments (A and B) and assessed.

A. Upper Arm, Lower Arm & Wrist

B. Neck, Trunk & Legs

The range of movement for each body part is divided into segments and recorded appropriately. The minimum score (Score 1) is accorded to the ranges of movement where the risk factors are minimal and higher numbers (up to 6) are given to ranges of movement with extreme postures. An individual Posture score (Score A and B calculated from

separate tables) is given to each body segment (Segments A and B) during analysis and these scores, along with muscle use score (muscle use scores are estimated for static postures held for longer than 1 minute or repeated more than 4 times per minute), and force scores (force score is estimated for total hours of work in a day), these are then read from a separate table to reveal the grand score (risk score).

The risk score ranges from 1 to 7 in which a score of 1 or 2 is acceptable, a score of 3 or 4 needs further investigation, 5 or 6 needs investigation and changes sooner and a score of 7 needs immediate investigation and change.

Modified RULA suitable for Dentists

The original RULA was developed to assess only one side of the body at a particular time for the selected work posture. To assess the other side of the body the assessment has to be repeated and the selected work posture to be assessed may have changed. To avoid this difficulty and to save time the RULA recording chart was modified and designed to record details of both sides of the body at the same time. A separate RULA score (risk score) for the right and left side was ascribed to each posture assessed²⁴.

The Dental Procedure

Photographs were taken when the students were operating on teeth in lower jaw of phantom head whilst preparing the teeth for a restoration. Figures 3 and 4 show a dental student in two different seats.

Analysis of Photographs:

The photographs of 60 students (30 students using BSS and 30 students using the CS) were analysed by the researcher using the modified RULA described above. Each student was given a risk score, which was used for statistical analysis.

Data Analysis

The hypotheses are two tailed. A Mann-Whitney Test was used to test the hypothesis that there will be a difference between the RULA scores achieved between the students using the BSS and CS. The level of significance of 0.05 was used for the rejection of the null hypothesis.

RESULTS

The photographs of 60 students were analysed using RULA. Figures 5 and 6 show the mean and standard errors for the right and left total scores comparing BSS and CS. The Mann-Whitney results were significant ($Z = -6.015$; $p < 0.01$) for the right total score and ($Z = -6.197$; $p < 0.01$) for left total score. The results confirmed that there was a significant difference in RULA Scores between the seats. Thus the null hypothesis can be rejected and the experimental hypothesis can be accepted. The results also indicated that the students using the CS recorded significantly higher RULA scores (Mean = 5.06 for the right side; Mean = 5.03 for the left side) when compared with the students using BSS (Mean = 2.80 for the right side; Mean = 2.66 for the left side) ($p < 0.01$), suggesting that there is a lower postural risk when using the Bambach Saddle Seat. The η^2 has been calculated to obtain the effect

size, the η^2 for right total score is 0.43 and η^2 for left total score is 0.45 which indicates large effect size.

DISCUSSION

The results indicate that there is a statistically significant difference between the risk scores of the BSS and CS. The students using the BSS were able to maintain an acceptable position on the observed joints (Upper Limb, Trunk and Lower Limb), which may be considered to contribute to a healthy working posture. The students using the CS appeared less able to maintain a healthy posture with the observed joint positions, indicating cause for concern. The results indicate that the standard deviation of the risk scores (Right and Left Grand Scores) for the students using the BSS were negligible when compared with the CS. However, the left grand score for the students using the BSS had indicated a standard deviation of 0.47 on risk scores. This may be because most of the students operate with the right hand and showed an acceptable risk score on the right side, whereas their left hand was kept at position of reduced risk, close to the body with joints in a safe range, thereby decreasing the final risk score from 3 to 2. There was variation in the position of the left hand, with some students holding the cheek of the phantom head in order to get an improved vision of teeth which were being operated on, while others used a mirror or rested their left hand on their thighs. The students using the CS recorded higher risk scores (mean of 5) with a standard deviation of 1.36 on both the sides observed, indicating poor posture. Even though the position of their left hand was similar to that of the students using the BSS, their slumped posture kept their joints at extreme ranges i.e. their shoulders were kept elevated and

abducted with their arm working across the midline of their body, thereby increasing the range of their final risk scores ranging from 3 to 7 indicating extreme concern which requires immediate investigation and changes.

The spine is in its natural curved position ('S' Shape) while standing, which enables the body's line of gravity to pass through the trunk and feet, so requiring minimal muscular activity to maintain the posture and to hold the trunk erect²⁵. Callaghan & McGill²⁶ found that standing produced a uniquely different spine posture compared with sitting, and standing spine postures did not overlap with flexion postures adopted in sitting. Sitting with a 90-degree angle between the trunk and the thighs causes the pelvis to rotate backwards shifting the spine away from the line of gravity (Fig. 1). This in turn reduces the lumbar lordosis¹², causing the spine to slump and increasing the load placed on the spine²⁷. Black et al²⁸ found that the movement of the lumbar spine influenced the movement of the cervical spine and identified slumped sitting posture (posterior pelvic tilt) as the poor posture for the spine. The students using the CS may have registered higher risk scores as a result of sitting in posterior pelvic tilt (kyphosis of the lumbar spine). They recorded higher risk scores in the neck (hyper flexion), shoulder (raised and abducted) and trunk¹⁰ (slumped / forward inclined) (Fig. 4) since the position of neck, shoulders and trunk are interrelated and an acceptable spinal posture is necessary to maintain good sitting posture^{27, 28}. On the other hand, the students using the BSS were able to maintain an acceptable position of the neck, shoulders and trunk, as they were able to maintain anterior pelvic tilted position contributing to the lower risk score (Fig 3). The BSS

is designed to maintain the pelvis in an anterior tilted position in order to achieve a slight lumbar lordosis²⁹ and the angle of hips and knees can be adjusted so that the spinal posture simulates standing, thereby contributing to a healthy spinal posture.

CONCLUSION

The RULA method applied to dental students' working postures allowed a rapid evaluation of their posture during simulated dental treatment. The RULA scores indicate that the students using the BSS are able to maintain an acceptable working posture (lower risk score), whereas for students using the CS the posture deteriorates over time (higher risk score). This may predispose to the development of musculoskeletal disorders. This study serves as a pilot trial and further studies in other dental schools and with practicing dentists is suggested.

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REFERENCES:

1. Finsen, L., Christensen, H., Bakke, M. Musculoskeletal disorders among dentists and variation in dental work *App. Ergonomics* 1998; 29 (2): 119-125.
2. Milerad E, Ekenvall L. Symptoms of the neck and upper extremities in dentists. *Scand J Work Environ Health* 1990; 16: 129-134.

3. Osborn J, Newell K, Rudney J, Stoltenberg J. Musculoskeletal pain among Minnesota dental hygienists. *J Dent Hyg* 1990b; 63: 132-138.
4. Rundcrantz B-L, Johnsson B, Moritz U. Cervical pain and discomfort among dentists. Epidemiological, Clinical therapeutic aspects. *Swed Dent J* 1990; 14: 71-80.
5. Oberg T, Oberg U. Musculoskeletal complaints in dental hygiene: a survey study from a Swedish country. *J Dent Hyg* 1993; 67: 257-261.
6. Akesson I, Lundborg G, Horstmann V, Skerfving S. Neuropathy in female dental personnel exposed to high frequency vibrations. *Occup Environ Med* 1995; 52: 116-123.
7. Finsen L. Biomechanical analyses of occupational work loads in the neck and shoulder. A Study in dentistry. PhD D thesis, National Institute of Occupational Health, Copenhagen, Human Physiology, August Krogh Institute at University of Copenhagen, Department of Oral Function and Physiology, School of Dentistry, 1995.
8. Shugars, D., Miller, D., Williams, D., Fishburne, C., and Strickland, D. Musculoskeletal pain among general dentists *Gen. Dent* 1987 35(4).
9. Burke, F.J.T., Freeman, R. The practice of dentistry: an assessment of reasons for premature retirement 1997 *Brit. Dent. J* 182: 250-254
10. Lake, J. Musculoskeletal Dysfunction associated with the Practice of Dentistry – Proposed Mechanisms and Management: Literature Review *Univ Tor Dent J*. 1995; 9(1): 7-11.

11. Nachemson, A. The lumbar spine: An orthopedic challenge. *Spine* 1976; (1) 1.
12. Grandjean, E. *Ergonomics in the Home*. London: Taylor and Francis, 1973.
13. Beach, T.A.C., Parkinson, R.J., Stothart, J & Callaghan, J.P. Effects of prolonged sitting on passive stiffness of the in vivo lumbar spine. *The Spine Journal* 2005; 5: 145-154
14. McGill SM, Brown S. Creep response of the lumbar spine to prolonged flexion. *Clinical Biomechanics* 1992; 7: 43–46.
15. Mannion, A.F. Fibre type characteristics and function of the human paraspinal muscles: normal values and changes in association with low back pain. *Journal of Electromyography and Kinesiology* 1999; 9: 363-377
16. Gunning, J., Callaghan, J.P., McGill, SM. The role of prior loading history and spinal posture on the compressive tolerance and type of failure in the spine using a porcine trauma model. *Clinical Biomechanics* 2001; 16: 471–480.
17. Bogduk, N. *Clinical anatomy of the lumbar spine and sacrum*, 4th ed. Churchill Livingstone, Edinburgh, 2005.
18. Moseley, G.L. Impaired trunk muscle function in sub-acute neck pain: etiologic in the subsequent development of low back pain? *Manual Therapy* 2004 9: 157-163
19. Snijders, C.J., Bakker, M.P., Vleeming, A., Stoeckart, R., Stam, H.J. Oblique abdominal muscle activity in standing and in sitting on hard and soft seats. 1995 *Clinical Biomechanics* 10(2): 73-78
20. Pheasant. *Ergonomics Work and Health* McMillan Press U.K, 1991.

21. Pynt, J., Higgs, J., Mackey, M. Seeking the Optimal Posture of the Seated Lumbar Spine *Physiotherapy Theory and Practice* 2001; 17, 5-21.
22. McAtamney, L., and Corlett, E.N. RULA: a survey method for the investigation of work related musculoskeletal disorders. *Applied Ergonomics* 1993; 24(2): 91-9.
23. Random Number Generator <http://www.segobit.com/rng.htm> 27/07/2006.
24. Nguyen, B.D. Musculoskeletal Problems and Occupational Stress among Dentists and Dental Assistants in a Dental Clinic. National Institute of Occupational and Environmental Health, Vietnam. *Occup Environ Med* 2004; 61: e57 (<http://www.occenvmed.com/cgi/content/full/61/11/e57>) 27/07/2006.
25. Corlett, E. N., and Eklund, J. A. E. How does a back rest work? *Applied Ergonomics* 1984; 15: 111-14.
26. Callaghan, J.P. & McGill, S.M. Low back joint loading and kinematics during standing and unsupported sitting *Ergonomics* 2001; 44(3): 280-294
27. Hedman, T.P., Fernie, G.R. Mechanical Response of the Lumbar Spine to Seated Postural Loads *Spine* 1997 22(7): 734-743
28. Black, K.M., McClure, P., Polansky, M. The Influence of Different Sitting Positions on Cervical and Lumbar Posture *Spine* 1996 21(1); 65-70
29. Gale, M., Feather, S., Jensen, S., and Coster, G. Study of a Workseat Designed to Preserve Lumbar Lordosis *AOTJ* 1989 36(2): 92-99

Figures:

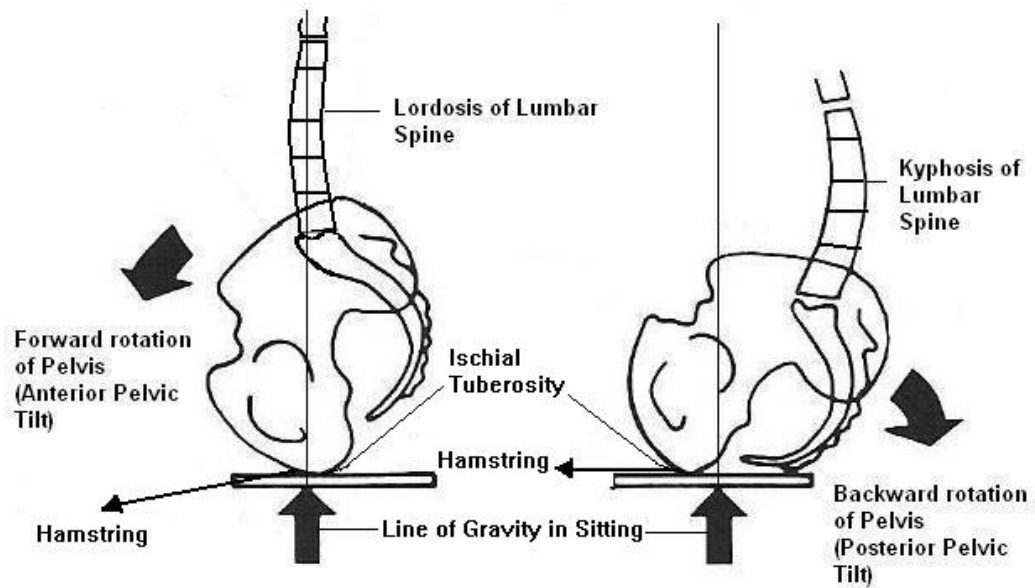
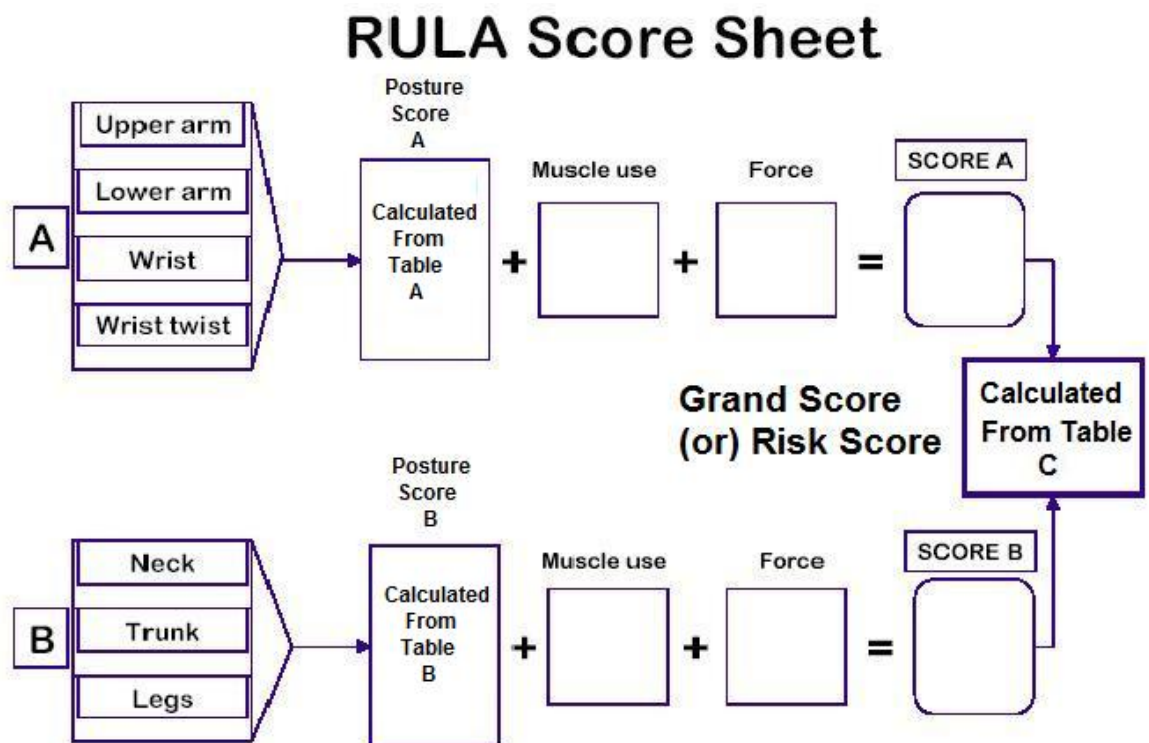


Fig 1. Sitting Posture (Anterior and Posterior Pelvic Tilt)



↓

Calculated From Table C

Grand Score (or) Risk Score

Fig 2. RULA Scoring Sheet (Adapted from McAtamney and Corlett²²1993)



Fig 3. A Dental Student Working on a Bambach Saddle Seat
(Reproduced with permission from Bambach)



Fig 4. A Dental Student Working on a Conventional Seat

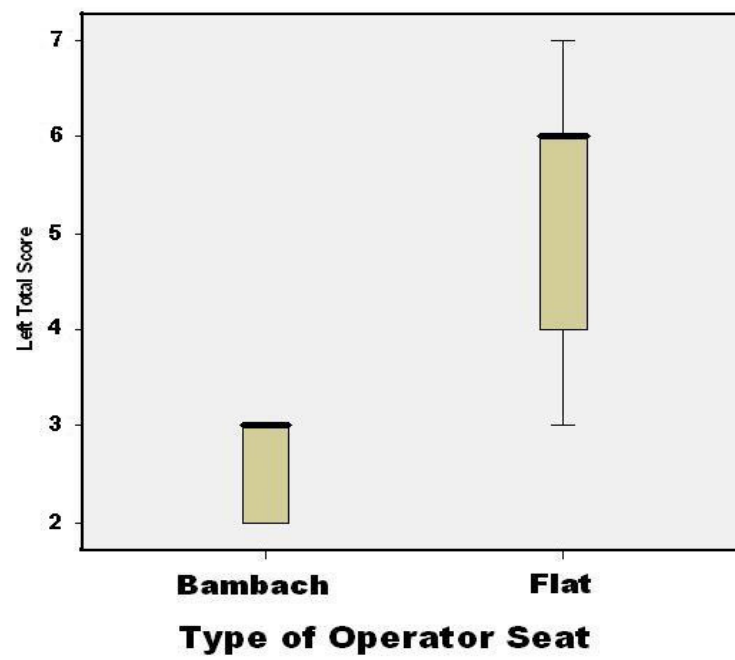


Fig 5. Box plot showing the Left Grand Score

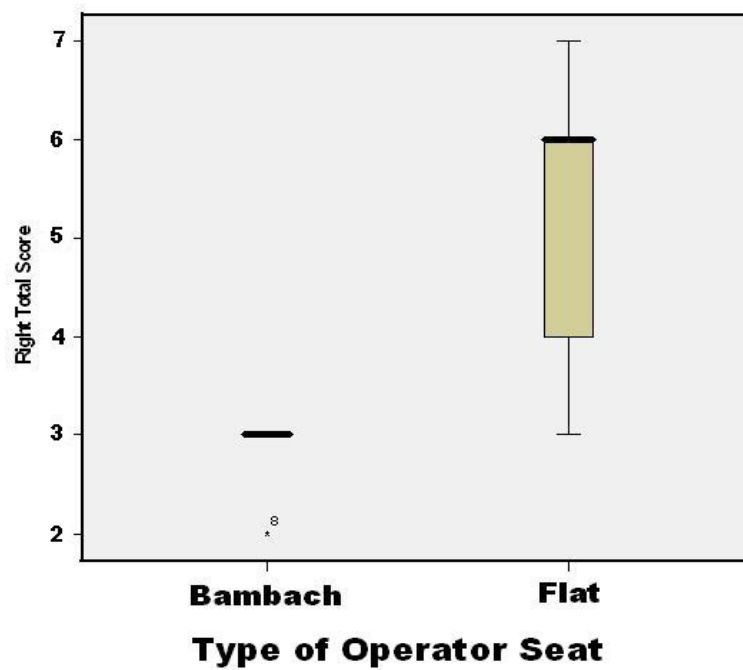


Fig 6. Box plot showing the Right Grand Score